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Farm Silos

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CONTENTS

Page
TYPES OF SILOS AND THEIR SELECTION 1
PERMANENT SILOS 2
Tower Silos 2
Monolithic concrete silos 11
Concrete-stave silos 11
Metal silos 12
Tile silos 12
Brick silos 12
Wood-stave silos 12
Wooden-hoop silos 13
Horizontal Silos 15
Bunker silos 19
Trench silos 22
Stack silos 24
TEMPORARY SILOS 24
Fence Silos 25
Upright Stack Silos 26

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Farm Silos

By J. R. McCalmont, Agricultural Engineering Research Division, Agricultural Research Service

The silo is a conspicuous building on farms in all parts of the country. Each year it is more important in supplying forage for livestock. From none in 1875, when the making of silage in the United States was first recorded, the number of silos of all types has increased to more than 900,000, storing more than 70 million tons of silage. This increase has been the outgrowth of many changes in the farm situation, including (1) an increase in numbers of livestock, (2) a decrease in pasture acreage, (3) an increase in grassland farming for soil conservation, (4) mechanization of farm operations, and (5) the growing practice of feeding greater amounts of silage. Also, farmers now recognize that the amount of protein supplement needed when feeding low- to average-quality hay or corn silage can be reduced by feeding high-protein grass silage and that ensiling is an excellent way to carry over excess feed from good years to poor years and from periods of lush spring growth to periods of summer shortage.

TYPES OF SILOS AND THEIR SELECTION

In choosing a silo, you must consider your service requirements, your available cash and time, initial cost of the silo, and its upkeep and efficiency in preserving forage. Losses vary with the type of silo, the crop ensiled, its stage of maturity and moisture content, fineness of chopping, and the efficiency of excluding air and water from the silage. In permanent upright silos losses range from 5 to 20 percent in gas-tight silos and from 10 to 20 percent in other types. In permanent horizontal silos losses range from 10 to 30 percent; and in temporary trench, fence, and stack silos, from 15 to 50 percent.

You can determine for yourself the type of silo that will best suit your system of cropping and feeding and that is obtainable for the funds available. Many farmers, by using a temporary silo for a few years, have accumulated sufficient capital through saving on their feed bills, to pay for a permanent silo.

Permanent tower silos built of brick, concrete, metal, or tile are attractive, durable, and fire and wind resistant. Use of unloaders and conveying systems reduces to a minimum the hand labor required for feeding.

Large tower silos ranging from 24 to 36 feet in diameter are being used to store feed for big feeding operations. Some of these have three or four sets of doorways to facilitate hand feeding, but most have only one and the silage is fed out from the center through a drag trench at the bottom. A plug 2 to 2½ feet in diameter and 6 feet long is pulled up through the center as these silos are filled. This leaves a chimneylike opening from the top to the bottom of the silo. A simple silo unloader scrapes the silage to the center, where it drops to the bottom of the silo and is delivered to feed trucks or bunks with a drag or screw conveyor.

A prefabricated porcelainized steel silo is also available. The glasslike coating is applied on both sides of the metal. This silo is airtight to prevent spoilage of the silage and is emptied from the bottom with a mechanical unloader. To maintain airtightness, the silo should be operated according to the manufacturer's recommendations. An advantage of this silo is that it can be partly loaded at intervals with different crops without appreciable loss in silage quality and with no top spoilage.

Several manufacturers, the New Jersey Agricultural Experiment Station, and others are working on the development of a self-feeding arrangement for upright silos. Various types of baffles and pins are being used to control and limit the speed with which the silage feeds into the feed trough. The idea is sound, and some progress has been made in reducing the amount of handwork. However, no system has been developed as yet to eliminate all safety hazards and handwork in feeding, especially where the silage freezes.

Permanent horizontal silos are generally considered less attractive, but they cost less per ton of storage and offer you the advantage of self-feeding with a low-cost feeding gate or mechanical feeding with your tractor loader or with an ensilage unloader.

Temporary silos are useful in an emergency such as that brought about by drought, destruction of buildings by fire, or some other unforeseen circumstance. They are sometimes used when sufficient money is not available to build a more substantial structure. However, the percentage of spoilage in temporary silos is higher than that in the more substantial structures.

PERMANENT SILOS

TOWER SILOS

General Construction.—1. The walls should be airtight. Doors must fit tightly.

2. Walls should be smooth and plumb and circular in form to provide structural strength and to permit free settling and packing of silage without air pockets.

3. Walls must be strong enough to withstand considerable lateral strain without cracking or bulging. Lateral pressures increase with the depth of the silage and vary with the kind of silage and its moisture content. The deeper the silage the greater the average capacity per foot of depth; with greater pressure more air is squeezed out and there is less spoilage.

4. Exterior wall surfaces should be protected where necessary to retard weathering and decay.

5. The foundation should be well drained and strong enough to support the load and to avoid uneven settlement and cracking of walls.

6. The silo should have a chute to facilitate feeding and a safe ladder giving access to the filling door.

7. A roof is desirable and is essential if a mechanical unloader is used.

Location.—Since the amount of time, travel, and labor spent on feeding livestock is one of the factors limiting the number of animals one man can handle, considerable emphasis is being placed on the location of silos and on arrangements for self-feeding or semiautomatic feeding of the silage.

On dairy farms where cows are housed in stanchion barns, build the silo a few feet from the barn and connect it to the barn by a feed room. With the loose housing arrangement, build the silo in or adjacent to the feeding area to reduce the time and travel required for feeding.

On beef-cattle farms, build the silo in or beside the feed lot.

Locate the silo so that the wagons and trucks used during filling can be operated with a minimum of turning and backing.

Size and Capacity.—The correct diameter of the silo depends on the quantity of silage to be fed daily. To prevent spoilage, silage should be removed at the rate of 2 to 3 inches a day, depending on the air temperature. In winter, probably 2 inches should be removed. More must be removed in warm weather. Don't build a silo too large in diameter for the size of your herd. If you reduce the size of your herd to a point where low consumption results in spoilage when you feed off the entire surface, feed to a depth of 1 to 2 feet on alternate halves. For large herds, build several silos. You can store different crops in the various silos and feed from them separately or together.

The weight of a cubic foot of silage varies with depth in the silo, rate of filling, length of cut, kind and maturity of material, and moisture content. Corn silage that is put up when about 75 percent of the grain has passed the milk stage and that contains approximately 72 percent of moisture is considered normal corn silage. So-called grass silage (silage made of grasses, legumes, and cereal crops, either alone or in combination) weighs from 5 to 10 percent more than normal corn silage.

Dairy cows fed silage as the sole roughage may require 100 pounds or more a day per cow. On the other hand, cows fed silage instead of soiling crops as a pasture supplement during summer droughts and in early fall may need as little as 10 pounds a day per cow, depending on the acreage and quality of pasture or other succulent feeds available. For the same herd, the silo used for summer feeding should be smaller in diameter than the one used for winter feeding, since 3 inches of silage should be removed daily in summer as compared with 2 inches in winter. To provide for feeding small herds in summer, an additional silo of smaller diameter is desirable.

When you know how much silage you are going to feed each day, you can estimate the diameter of the silo you need to permit removal of a certain depth each day. Tables 1 and 2 show the diameter of silo needed for herds of different sizes for winter and summer feeding.

In general, the height of the silo should be not less than twice nor more than four times the diameter. The greater the depth of silage the better the quality and the greater the unit capacity. Avoid extremely tall silos, however, because of the excessive power required to elevate the fresh chopped silage.

Once you have determined the diameter of silo you need for your herd, you can find the total amount of silage for a year's feed supply by multiplying the amount to be fed each day by the number of days in the feeding period. Use table 3 to help you determine the height of silo you need to store that amount of silage.

For example, suppose you have a herd of 20 cows and plan to feed 60 pounds of silage a day for 240 days. The cows would eat 1,200 pounds of silage a day or 288,000 pounds (144 tons) a year. If you allow 10 percent for losses, you will need a 14-foot-diameter silo filled to a depth of 45 feet.

You may wish to know about how much silage you have in your partly emptied silo. Many factors affect the unit weight of silage; therefore, tables can give only a rough estimate as a substitute for weighing. However, you can use the data in table 4, based on the weight of well-settled corn silage, to make an estimate. Suppose, for example, you stored 40 feet of silage in your 14- by 45-foot silo, and have removed 20 feet. More than half of the silage by weight remains because that in the lower 20 feet is more compact than that in the

Table 1.—*Relation of size of herd to diameter of silo for winter feeding* [1]

Inside diameter of silo (feet)	Volume per foot of depth	Amount to be removed—				Animals that may be fed with a daily allowance of—			
		Daily	For feeding period of—						
			120 days	180 days	240 days	80 pounds	60 pounds	40 pounds	20 pounds
	Cubic feet	*Pounds*	*Tons*	*Tons*	*Tons*	*Number*	*Number*	*Number*	*Number*
8	50. 3	419	25	38	50	5	7	10	21
10	78. 5	654	39	59	78	8	11	16	33
12	113. 1	942	57	85	113	12	16	24	47
14	153. 9	1, 282	77	115	154	16	21	32	64
16	201. 0	1, 675	101	151	201	21	28	42	84
18	254. 5	2, 121	127	191	255	27	35	53	106
20	314. 2	2, 618	157	236	314	33	44	65	131

[1] Basis: 50 pounds of silage per cubic foot; 2 inches removed daily to avoid spoilage.

Table 2.—*Relation of size of herd to diameter of silo for summer feeding* [1]

Inside diameter of silo (feet)	Volume per foot of depth	Amount to be removed—				Animals that may be fed with a daily allowance of —			
		Daily	For a feeding period of —						
			60 days	90 days	120 days	80 pounds	45 pounds	20 pounds	10 pounds
	Cubic feet	*Pounds*	*Tons*	*Tons*	*Tons*	*Number*	*Number*	*Number*	*Number*
8	50. 3	629	19	28	38	8	14	31	63
10	78. 5	981	29	44	59	12	22	49	98
12	113. 1	1, 414	42	64	85	18	31	71	141
14	153. 9	1, 924	58	87	115	24	43	96	192
16	201. 0	2, 513	75	113	151	31	56	126	251
18	254. 5	3, 181	95	143	191	40	71	159	318
20	314. 2	3, 928	118	177	236	49	87	196	393

[1] Basis: 50 pounds of silage per cubic foot; 3 inches removed daily to avoid spoilage.

Table 3.—*Capacity of tower silos in tons of corn silage*

(68 to 72 percent moisture [1])

Average weight per cubic foot	Depth of silage	Capacity with an inside diameter of—									
		12 feet	14 feet	16 feet	18 feet	20 feet	22 feet	24 feet	26 feet	28 feet	30 feet
	Feet	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
44	30	75	102	133							
47	40	106	145	189	239	295	357	425	499	579	665
49	50	138	189	246	311	385	466	554	650	755	866
51	60	---	236	308	389	480	581	692	812	942	1, 082
53	[2] 70	---	---	373	471	582	705	838	985	1, 143	1, 311
55	[2] 80	---	---	---	---	691	836	994	1, 168	1, 355	1, 515

[1] Basis: Silo filled with normal corn silage at the average speed of 20 to 50 tons per day; refilled once after silage has settled and the top has been well tramped. For grass silage, capacity is increased from 5 to 10 percent.

[2] Not recommended. Added height requires more power for filling and more work for feeding out and/or maintenance.

upper 20 feet. The volume of silage per foot of depth in a silo with a diameter of 14 feet is 153.9 cubic feet (table 1). Table 4 gives the average weight of silage as 44.3 and 49.5 pounds per cubic foot at 20 and 40 feet, respectively. Initially, the silo contained 40×153.9×49.5, or 304,722 pounds of silage. The amount removed from the upper 20 feet was 20×153.9×44.3, or 136,355 pounds. This leaves 168,367 pounds (304,722−136,355), or about 84 tons in the silo.

The sale price of silage often is based on its equivalent feeding value with respect to corn and hay. Studies in Illinois show that a ton of corn silage ordinarily contains 4.6 bushels of grain, and the stalks and leaves are about equal in value to 270 pounds of mixed hay. The feeding value of silage is also considered about one-third the value of good leafy alfalfa hay. Hence the local price of hay and grain may be used to determine a fair price for sale or for trading. These data used with the data in table 4 are often useful for farm inventory and other purposes.

Cost.—The cost of building a silo depends on the size and type of silo and the price of materials and labor. In general a silo built with farm labor of local materials will have a lower first cost, but a silo built by a reputable manufacturer may cost less over the period of its life. Table 5 gives an estimate of the cost of permanent upright silos.

Table 4.—*Weight of settled silage per cubic foot to a given depth when the silo is full*[1]

Depth of settled silage (feet)	Average weight per cubic foot (pounds)	Depth of settled silage (feet)	Average weight per cubic foot (pounds)
1	17. 7	26	46. 4
2	23. 5	27	46. 7
3	26. 9	28	46. 9
4	29. 5	29	47. 2
5	31. 6	30	47. 4
6	33. 3	31	47. 7
7	34. 7	32	47. 9
8	36. 0	33	48. 1
9	37. 1	34	48. 3
10	38. 1	35	48. 5
11	39. 0	36	48. 7
12	39. 8	37	48. 9
13	40. 6	38	49. 1
14	41. 2	39	49. 3
15	41. 8	40	49. 5
16	42. 4	41	49. 7
17	43. 0	42	49. 9
18	43. 5	43	50. 0
19	43. 9	44	50. 2
20	44. 3	45	50. 3
21	44. 7	46	50. 5
22	45. 1	47	50. 6
23	45. 5	48	50. 8
24	45. 8	49	50. 9
25	46. 1	50	51. 0

[1] Basis: Corn silage (moisture content, 72 percent), as fed out of silo. Grass silage under the same conditions averages from 5 to 10 percent heavier than corn silage.

Table 5.—*Approximate cost of permanent upright silos per ton of stored silage (roof and chute included)*[1]

Capacity	Cost per ton	Capacity	Cost per ton
Tons	*Dollars*	*Tons*	*Dollars*
25–50	24–54	100–150	12–30
50–100	14–40	150–300	10–25

[1] These figures, based on silos with heights of from 2 to 4 times the diameter, were compiled from actual costs to farmers, contractors' estimates, and manufacturers' retail price lists of 1957.

Foundations.—Foundations stand up well only on firm well-drained soil and only if they extend below the frostline. In the North they should extend 4 feet or more below the ground surface; in the South at least 2 feet. The width of the foundation base needed depends on the kind of soil and the load to be supported. The foundation must be wider on loose soil than on firm soil. The walls carry from 30 to 60 percent of the total weight of the silage, depending on the roughness of the walls and the character of the silage. In tests at the Agricultural Research Center, Beltsville, Md., 60 percent of the weight of normal corn silage stored in a 14- by 45-foot monolithic concrete silo was supported by the walls. Experiments with self-feeding silos have shown that at times the entire weight of silage is carried by the walls after feeding starts.

The expected foundation load per foot of circumference of silo walls of different heights and the size of footing needed are listed in table 6. The size of footing is based on firm dry soil with a load-bearing capacity of at least 2½ tons per square foot. If you plan to build a tall silo or a bottom self-feeding silo, consult a reliable local builder as to the bearing value of the subsoil and the size of footing to use.

Table 6.—*Load per foot of circumference and width of footing needed for silos of different heights on soil with a bearing capacity of 2.5 tons per square foot*

Height of silo wall (feet)	Load and width of footing for silo walls of—					
	6-inch monolithic concrete		2½-inch concrete stave or 5-inch tile		2-inch wood or metal	
	Load per foot of circumference	Width of footing	Load per foot of circumference	Width of footing	Load per foot of circumference	Width of footing
	Tons	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*
20	1. 5	8	1. 0	8	0. 8	8
30	2. 5	12	2. 0	10	1. 5	8
40	4. 0	20	3. 0	15	2. 7	13
50	5. 7	28	4. 4	22	------	------
60	7. 8	38	6. 5	32	------	------

Build the footing of concrete on uniform type of undisturbed soil—never partly on rock and partly on soil. Also, fill in low places with concrete to level off the bottom excavation for the footing; never use loose soil.

The foundation wall below grade may be concrete, hard-burned brick (8 inches thick), or hard, flat stones (not less than 12 inches thick). Lay brick and stone foundations in portland cement, not lime mortar. Concrete walls are stronger than brick or stone and permit better anchorage for the superstructure. Reinforce foundation walls that extend above the ground the same as the walls above.

The depth of the footing should be not less than 8 inches nor less than the difference in width between the foundation wall and footing. For example, a footing 20 inches wide that supports a foundation wall 8 inches wide should be not less than 12 inches deep.

Lay out the foundation for a round silo as follows: Use a 2- x 4-inch scantling a little longer than half the diameter of the silo plus the width of the foundation wall. Drive a stake into the ground where the center of the bottom of the silo is to be. Then drive a fortypenny spike through one end of the scantling and into the top of the stake. From the spike, measure off on the scantling the distance to the outside of the foundation wall or footing, and nail on a marker with which to lay off the foundation line, as shown in figure 1.

If the building site is not level, use a longer marker. Hold the scantling level as you move it around the circle and move the marker up or down as you mark the foundation. If the ground is very uneven and it is difficult to make a continuous line, make points every few inches and join them afterward.

Move the marker toward the center stake a distance equal to the width of the wall or footing, and lay off a second circle to mark the inner side of the foundation.

If your soil is firm, you may not need a footing for the foundation, but can pour the concrete directly into the trench for the foundation (fig. 2, *A*). When depositing the concrete be sure loose dirt does not fall from the upper edges of the trench walls into the fresh concrete. This might weaken the foundation wall considerably. Protect the earth wall with a tarpaper lining while pouring the concrete. Use a plumb line so you can dig the walls true.

If the dirt is apt to cave in, build the foundation as shown in figure 2, *B* and *C*. Allow room for placing and removing the outside form. Many failures of masonry structures have been caused by poor and insufficient foundations. Be sure the concrete footing is big enough for the load, as shown in table 6, and build it as illustrated in figure 2, *B* and *C*.

Figure 3 shows how to build forms for a foundation wall extending aboveground and how to place the anchors for holding the walls. The anchors may be machine bolts, strap iron, eyebolts, or reinforcing iron, depending on the type of silo. Space the anchors so they can be easily fastened and give firm anchorage to the wall. For masonry silos, extend the wall reinforcing into the foundation or footing. For wood-stave silos, make the inside diameter of the foundation wall 4 inches less than the inside of the silo. This provides a 2-inch shoulder between the inside of the silo wall and the inside of the foundation to allow for shrinkage and expansion of staves and for imperfections in the wall.

If you use concrete, the following information is helpful:

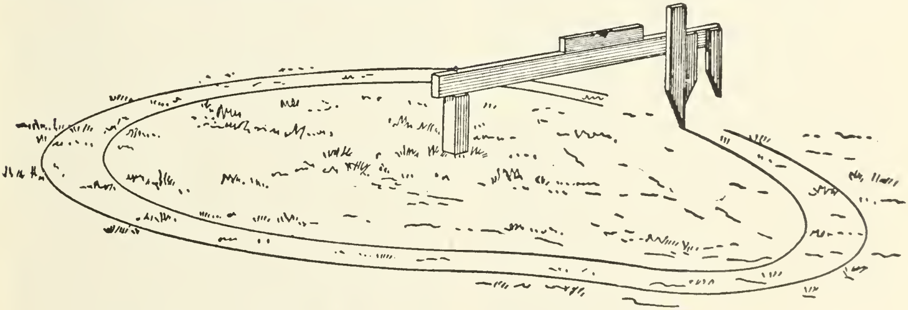

FIGURE 1.—Method of laying off the foundation for a silo.

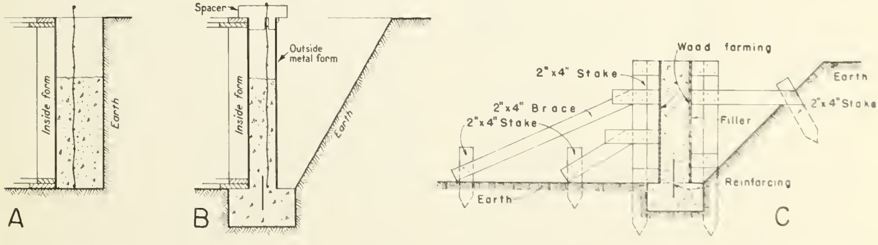

FIGURE 2.—*A*, Method of constructing foundation without footing for monolith silo in firm soil; *B*, method used for monolith silo when footing is required; *C*, built-up forms for foundation walls.

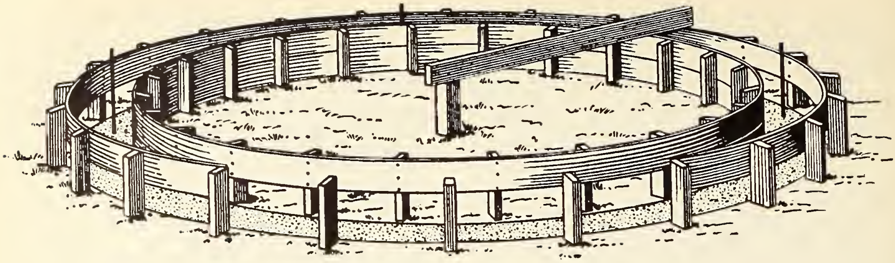

Figure 3.—Form for foundation extending aboveground, partly boarded up.

Except for very large silos, concrete made of 1 part of cement, 2½ parts of sand, and 4 parts of gravel is suitable for foundations.

Use a standard portland cement; keep the sacks of cement in a dry place and off the ground. Obtain a good, clean, coarse sand; and clean, coarse aggregate of gravel or broken stone graded in size from ⅜ to 1½ inches. Mix these together with clean water free from acids or alkali. Water fit to drink is suitable for concrete; do not use drainage water from the barnyard or muddy water. Mix the concrete to a workable consistency with the least amount of water that will give easy delivery to forms without being sloppy—usually about 4 or 5 gallons of water to a sack of cement, depending on the dryness of the aggregate. Tamp the concrete well to eliminate air pockets.

Although you can make satisfactory concrete by hand mixing, machine mixing is recommended. Table 7 gives some mixtures commonly used for mortar, plaster, footings, and walls and may be used to estimate the quantity of material required. A sack of cement is approximately 1 cubic foot.

Helpful booklets on mixing and placing can be obtained from most cement dealers.

Floors and Drains.—Floors can be the natural soil of the site, porous fill, concrete, or masonry. Concrete and masonry floors are easier to clean and keep rats from burrowing underneath the foundation wall but add considerably to the cost of the silo. Regardless of the kind of floor, provide adequate drainage. Silage juices do not move vertically through the mass of silage. Therefore, provide drainage channels around the silo wall, as shown in figure 4, *A*, *B*, and *C*. Silage that contains more than 74 percent of moisture or that is made of material chopped very fine requires vertical wall drainage channels. Pipes, poles, or 2 x 4's set against the wall at about 4-foot intervals (as shown in figure 4, *C*) permit the juices forced from the silage by the pressure above to travel down to the floor drains. If the silage contains more than 74 percent of moisture, carry the poles to within 5 feet of the top of the silage.

Table 7.—*Proportion and approximate quantity of materials required for making 1 cubic yard of concrete in place*

Proportion			Quantity [1]		
Cement	Sand	Gravel or stone	Cement	Sand (damp and loose)	Gravel (loose)
			Sacks	*Cubic yards*	*Cubic yard*
1	1. 5	--------	15. 5	0. 86	--------
1	2. 0	--------	12. 8	. 95	--------
1	3. 0	--------	9. 6	1. 07	--------
1	2. 0	3. 5	6. 5	. 48	0. 84
1	2. 5	4	5. 6	. 52	. 83

[1] Quantities may vary as much as 10 percent, depending on the aggregate.

Make concrete and masonry floors at least 4 inches thick, slope them approximately ½ inch per foot from the wall to the drain, and extend channels radially from the drain to the wall (fig. 4, *A*). The channels permit silage juices that flow down along the walls or vertical drains to reach the floor drain.

Reinforcing.—All silos must be reinforced to withstand the bursting pressure exerted by the silage and the collapsing or overturning forces of high winds. The reinforcing needed depends on the dimensions of the silo. Lateral pressures in silos vary with the diameter and height of the silo and with the type and moisture content of the material ensiled. In cooperative experiments by the Agricultural Research Service and the New Jersey Agricultural Experiment Station, pressures were measured in 20 separate tests over a 7-year period. The results show that design pressures (in pounds per square foot of wall surface at a given height safe for all types of silage with a maximum moisture content of 74 percent) can be based on the following formulas:

Diameter of silo

14 feet or less: Lateral pressure $=\frac{dh^{1.2}}{2.56}$;

16 feet or more: Lateral pressure $=\frac{dh^{1.45}}{5}$

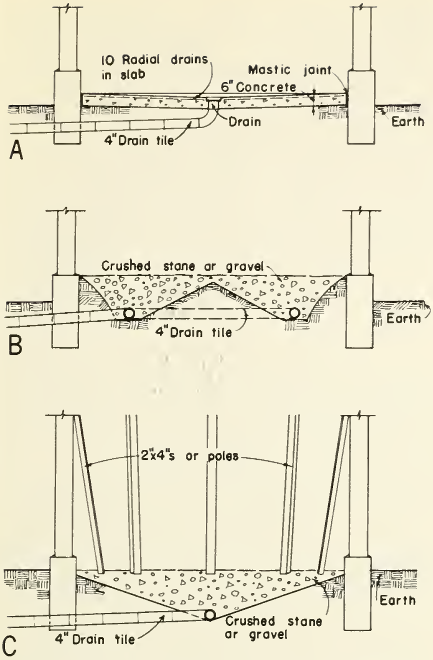

FIGURE 4.—*A*, Concrete floor with radial drainage channels sloping from wall to center drain; *B*, granular (gravel or crushed rock) floor with circular tile drain; *C*, granular floor with center drain showing vertical drainage channels for high-moisture silage.

TABLE 8.—*Spacing of $\frac{9}{16}$-inch hoops for stave silos* [1]

Distance of hoop below top (feet)	Spacing for a silo with a diameter of—					
	10 feet	12 feet	14 feet	16 feet	18 feet	20 feet
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
0 –20	30	30	30	30	30	30
20 –22½	30	30	30	15	15	15
22½–25	30	30	30	15	15	10
25 –27½	30	30	30	15	15	10
27½–30	30	30	15	15	10	10
30 –32½	30	30	15	15	10	10
32½–35	30	30	15	10	10	7½
35 –37½	30	15	15	10	7½	7½
37½–40	30	15	15	10	7½	6
40 –42½	------	15	15	10	7½	6
42½–45	------	15	15	10	6	5

[1] All hoops to have rolled threads and the next larger size of nuts. Use ⅝-inch hoops if $\frac{9}{16}$-inch are not available. Figures in this table are based on a safe working stress of 20,000 pounds per square inch (for silages containing up to 74 percent of moisture). For silages with a moisture content higher than 74 percent, provide vertical drainage channels on the inside surface of the silo walls.

where d is the diameter and h the height of the silo in feet. Silage containing more than 74 percent of moisture, however, produces higher pressures that will stress the reinforcing above the 20,000 pounds per square inch safe working stress. Silo walls should be provided with vertical drainage channels on the inside surface when very wet silage (moisture content more than 74 percent) is to be stored.

Reinforce wood, tile, or concrete stave silos with hoops placed around the outside, as indicated in table 8. Reinforce masonry silos, such as tile, brick, or concrete block, with wire, round or square rods, or iron flats placed in the mortar joints between courses (table 9). Be sure to space and tighten the hoops properly. To avoid stripping, give each nut enough turns to show several threads outside the nut. Use hoops with rolled threads (so as not to reduce the cross-sectional area of the rod) and the next larger size of nut. Hoops may be either plain or galvanized. Paint plain hoops to prevent weakening by rust and unsightly stains on the walls.

You may reinforce monolithic concrete silos with steel rods, bars, or wire mesh if you use enough of the reinforcing material to withstand the pressure. Common woven or welded steel-mesh reinforcing cloth, 32 to 36 inches wide, with horizontal wires ranging from No. 9 to No. 3 or larger is convenient to use and can be obtained at reasonable cost. The horizontal strength per square foot of this reinforcing should correspond to the sizes given in table 9. This wire is easy to place and keep in position while you are filling the form. Reinforcing wire should be free from sharp kinks or bends and, to be most effective, should be placed within 1 or 2 inches of the outer wall surface (fig. 2, *B*). Do not use old or damaged wire of unknown strength.

Doors and Doorways.—Silo doors must close tightly to prevent air leakage and must be flush with the inner wall to prevent formation of air pockets as the silage settles. Frames must be strong to resist silage pressure.

Two kinds of door openings are in general use—intermittent and continuous. A common size for doors is 20 inches wide by 30 inches high. The vertical space between the intermittent doorways is 2½ to 3 feet.

A continuous doorway is convenient for removing silage, but particular care is necessary in framing it to obtain the desired strength. Doors may be fitted with hooks or hinges so they can be closed or replaced as the silo is emptied, a practice that reduces draft through the silo, makes working conditions more comfortable, and prevents loss or misplacing of doors.

Chutes.—A chute is desirable on all silos to prevent scattering the silage. When building the doorframe, provide for attaching the chute. The reinforcing rods across a continuous doorway serve as a ladder. On other doorways attach a ladder to the chute. Climbing the silo will be easier and safer if the chute is not too large (approximately 30 inches wide and from 27 to 30 inches deep).

Table 9.—*Number of pieces of No. 3 reinforcing wire or 3/8-inch round bars required in masonry silos for horizontal reinforcing, spaced at 1-foot intervals* [1]

Distance below top (feet)	Pieces of reinforcing for silos with diameter of—					
	10 feet	12 feet	14 feet	16 feet	18 feet	20 feet
	Number	*Number*	*Nnmber*	*Number*	*Number*	*Number*
0	1	1	1	1	1	1
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	1	1	1	1	1	1
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	1	1	1	1	1	1
7	0	0	0	1	1	1
8	0	1	1	1	1	1
9	1	0	1	1	1	1
10	0	1	1	1	1	2
11	1	1	1	1	2	2
12	0	1	1	1	2	2
13	1	1	1	2	2	2
14	0	1	1	1	2	2
15	1	1	1	2	2	2
16	1	1	2	2	2	3
17	1	1	1	2	2	3
18	1	1	2	2	3	1
19	1	1	1	2	2	2
20	1	2	2	3	3	1
21	1	1	1	2	2	2
22	1	2	2	3	1	2
23	1	1	2	3	2	2
24	1	2	2	3	2	2
25	1	1	2	3	2	2
26	1	2	2	2	2	2
27	1	1	2	1	2	3
28	2	2	3	2	2	2
29	1	2	2	1	2	3
30	2	2	3	2	2	2
31	1	2	2	2	2	3
32	2	2	3	2	3	3
33	1	2	2	2	2	3
34	2	2	3	2	3	3
35	1	2	3	2	2	3
36	2	3	2	3	3	4
37	2	2	1	2	3	3
38	2	3	2	3	3	4
39	2	2	1	2	3	4
40	2	3	2	3	3	4
41	2	2	1	2	4	4
42	2	3	2	3	3	5
43	2	3	1	3	4	4
44	2	3	2	3	3	5
45	2	3	2	3	4	5

[1] Cross-sectional area of No. 3 reinforcing wire is 0.0467 square inch; for 3/8-inch rods, 0.1105 square inch. All figures below the horizonal line are for 3/8-inch round bars.

Spacing can be at intervals of 4, 8, 12, 15, 24, or 30 inches, according to the type of material and size of units used. Figures in this table are based on a safe working stress of 20,000 pounds per square inch (for silages containing up to 74 percent of moisture). For silages with a moisture content higher than 74 percent, provide vertical drainage channels on the inside surface of the silo walls.

Roofs.—Although a roof is not essential, it is desirable for several reasons. A roof (1) adds to the stability, appearance, and life of the silo, (2) retards freezing, (3) reduces spoilage by keeping rain and snow out, (4) protects a silo unloader from the weather, (5) discourages pigeons and sparrows from feeding on the silage and (6) makes the work of removing silage more agreeable. A simple trapdoor in the roof to admit the silage carrier or blower pipe is sufficient, but a glazed dormer window in the roof reduces the need for artificial light. If electricity is available, lights with reflectors in the top of the chute and roof are a great convenience and should be provided when the silo is built. The filling door should be easily accessible from a ladder or the chute, and a working platform should be provided for persons handling the filler pipe or elevator.

Gambrel, dome, and half-pitch roofs are most economical of space and provide more headroom for maximum filling (fig. 5). The form of anchorage for the roof plate varies with the type of construction. For stave silos pass strap bolts through the plate and bolt them to the tops of the staves. For masonry silos, set anchor bolts in concrete (fig. 6) or in top courses of tile or brick. A thin shell of concrete poured in a conical form makes a strong, durable roof for masonry silos. Factory-made roofs of galvanized metal or aluminum with movable sections that open to permit filling to the top are also available.

Lightning Protection.—The silo is usually the tallest building on the farm and forms a natural target for lightning. Destruction of silos or serious damage to masonry silos may be greatly reduced by installing lightning rods.

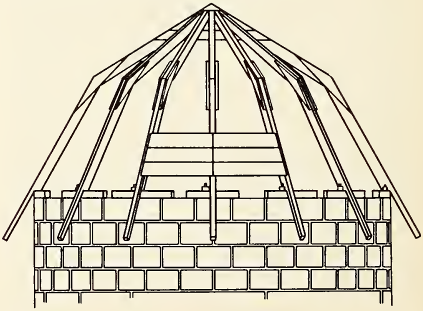

Figure 5.—Framing for a gambrel roof.

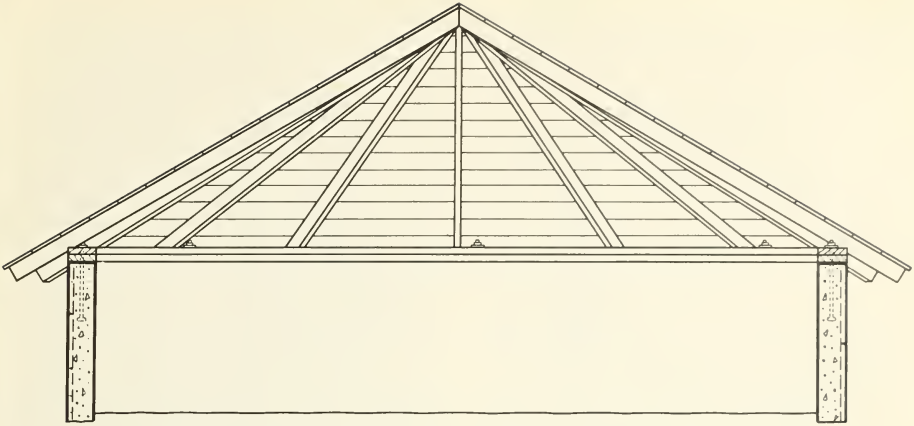

FIGURE 6.—Pitch-roof construction, showing anchorage of plate to a masonry wall.

Fasten the air terminal securely to the peak of the roof and attach the cable extending to the ground firmly, with a strong fastener, to the silo roof and walls. To complete the electrical connection, extend the down conductor to a ground 8 to 10 feet deep, until you reach permanently moist soil. Place the down conductor where it will not be easily damaged by wagons or trucks, and protect it from injury if necessary. If the barn is rodded, cross-connect the down conductor to the nearest down conductor on the end of the barn.

Scaffolding.—Safety is of first importance in the erection of scaffolding. In building or repairing tall silos it is particularly important that the scaffold uprights be plumb and firmly braced. It is a good practice to set them 4 to 6 inches in the ground. Uprights of 2- by 4-inch scantling doubled and overlapping at the joints are convenient. Long straight poles, however, often cost less. The number of uprights needed ranges from 7 for a small silo to 17 or more for a larger one when inside scaffolding is used (fig. 7). Brace the uprights to a center pole.

Although inside scaffolding is used in the erection of most silos, an outside scaffold is required for a wood-stave silo. Outside scaffolding consists of pairs of upright posts connected with horizontal bars spaced at intervals for the working platform. You will need from 8 to 18 or more pairs. Place the inner posts about 1½ feet from the silo wall so as to leave a clear working space, and connect the pairs with horizontal and diagonal braces as shown in figure 8.

Wall Treatments for New and Old Silos.—Any painting or treating of the walls of a new silo is best done before the scaffolding is removed. The interior surface of the walls should be smooth. Any coating applied should have a smooth, lasting finish, be impervious to silage acids, and stop air and water leakage. Among the common coatings

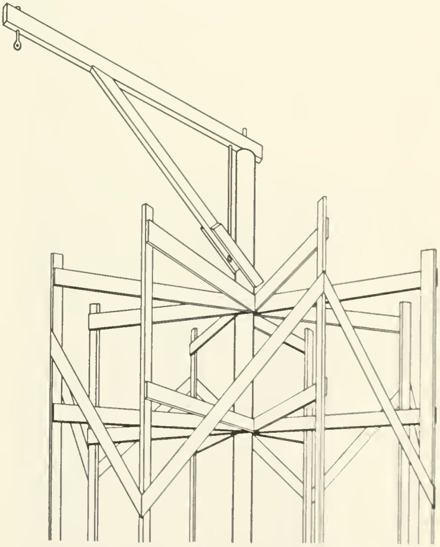

FIGURE 7.—Top section of inside scaffolding showing rotating device for hoisting material.

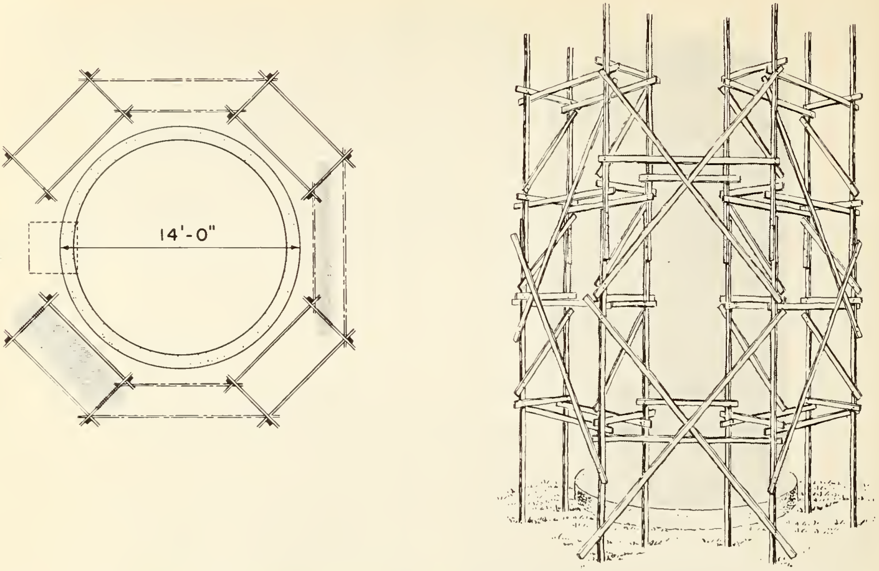

FIGURE 8.—Outside scaffolding for erecting a wood silo or repairing any silo.

that are effective for a few seasons are asphalt and some of the rubber base paints (for all kinds of walls) and plaster and cement wash (for masonry walls). Several new preparations with phenolic resin or plastic bases protect concrete or masonry for from 4 to 10 years. They are available from most silo manufacturers. Pressure-creosoted wood staves need no further treatment.

Silage acids have no effect on hard glazed tile, and for this reason some manufacturers make special silo tile that fit closely on the inside, leaving very little mortar exposed. A tile stave used with mastic in vertical and horizontal joints is unaffected by silage acids. Well-made concrete having an absorption of less than 5 percent is highly resistant to these acids, but careless mixing and poor workmanship may result in rapid deterioration. Special treatment of the interior surface of a silo will not adequately protect poor-quality concrete. It is much better to use high-quality concrete in the silo wall itself in the first place. A wash of cement and water of the consistency of thick paint may be applied to the wetted concrete wall to cover minor irregularities. Among the best-known coatings to prevent action of silage acids for from 1 to 3 years are raw or boiled linseed oil and asphalt preparations. When linseed oil is applied, the first coat may be thinned with 1 part of turpentine to 4 parts of linseed oil to obtain better penetration. This coating may be renewed from year to year as required.

Silage acids attack galvanized metal. Therefore, paint new silos of this material on the inside with linseed oil, or with one of the commercial preparations available for this purpose. Aluminum-flake paint on the exterior improves its appearance.

Proper upkeep and repair lengthen the life of a silo. Some farmers paint their silos with a low-cost preparation each year after the silage is fed out. Others apply more lasting coatings once in 3 to 5 years or more.

If you have an old masonry silo with poor mortar joints, you can recondition it by cleaning the walls, pointing the joints and cracks with rich cement mortar, and then painting them with a plastic, or asphaltic preparation. This is highly important with block or brick walls, where the reinforcing is between courses, for once the reinforcing has rusted out it cannot be replaced without tearing down the silo. If the walls leak, you might add a coat of rich cement plaster and check the amount of reinforcing to determine if additional bands are needed to prevent overstrain.

Concrete staves should be similarly protected against injury from silage juice. Since they are generally $2\frac{1}{2}$ to $3\frac{5}{8}$ inches thick there is not much safety margin for reduction in strength of the walls. If the staves become much thinner, they may fail when the silo is full. Well-made monolithic concrete walls need little attention except painting. If the concrete was poor quality and the silage acids have made it very rough, it may be necessary to scrape, wire brush, or sand blast and wash the walls thoroughly, and, after soaking them with water, add a coat of rich cement plaster.

Rotted parts of the walls of wood silos may be replaced, but it is better to keep the walls painted. Lead paints contaminate silage with poisonous lead and should never be used. Creosoting is probably the most favored treatment for wood walls. Various other commercial preparations are also used.

A metal silo should be kept painted from the time it is put up, since little can be done once the metal has rusted. Patches can be bolted or riveted over small damaged areas, but a silo so damaged is not likely to remain serviceable long. Where corrosion has just started, it can usually be stopped by thorough cleaning and painting. If the silo leaks where the sheets of metal come together, the old bolts can be replaced, a few at a time. The joints should be filled with mastic before the bolts are drawn tight.

Monolithic Concrete Silos

Masonry silos—concrete, tile, and brick—are cylindrical. Concrete silos may be of stave, block, or monolithic construction. The word "monolithic" as used here means a solid or 1-piece concrete wall. Title and brick silos differ mostly in size and shape of units. Because of their weight, freight can be a large factor in the cost; however, these materials are manufactured in many sections of the country.

Monolithic concrete silos have been built in most parts of our country and many are still serviceable after 40 years of continous use. When built of hard dense concrete they require a minimum of upkeep. However, high labor and form costs, and reduction in the amount of time a farmer has to build for himself, has caused a swing to other types of masonry silos. Instructions for building monolithic concrete silos can be obtained from the Portland Cement Association, 33 West Grand Avenue, Chicago 10, Ill.

Most monolithic silos are now built by local contractors who use metal forms. Some contractors use a continuous process in which patented forms are slowly but continuously jacked up as the concrete is poured.

With careful workmanship and a trained crew, a satisfactory silo of medium height can be built with a 4-inch wall, but most builders find 6-inch walls easier to build. The same thickness should be continued to the top because of the difficulty of adjusting the forms for a wall of decreasing thickness.

Concrete-Stave Silos

Concrete staves for silo walls are available in many parts of the country. They are generally 10 inches wide, 30 inches long, and $2\frac{1}{2}$ inches thick. The staves are bound together with hoops, the joints are sealed, and the surface is finished with cement plaster or a cement wash and painted with a plastic sealer (fig. 9). The size and spacing of the hoops are given in table 8.

If you purchase concrete staves for a silo, be sure to obtain staves that are guaranteed by the manufacturer to meet the standards for construction of concrete farm silos issued by the American Concrete Institute, P.O. Box 4754, Redford Station, Detroit 19, Mich. If you plan to build an unusually tall silo, hire a competent engineer to design a foundation to take care of the excessive wall loads due to silage and wind pressures. The manufacturers of concrete-stave silos generally quote prices on a silo set up on the farm and often include foundations.

Precast concrete door frames are generally most satisfactory for this type of silo. The chute usually is made of staves and requires 7 or 8 staves from silo wall to silo wall. Support the chute on an iron bracket and bind it to the silo with supplementary hoops.

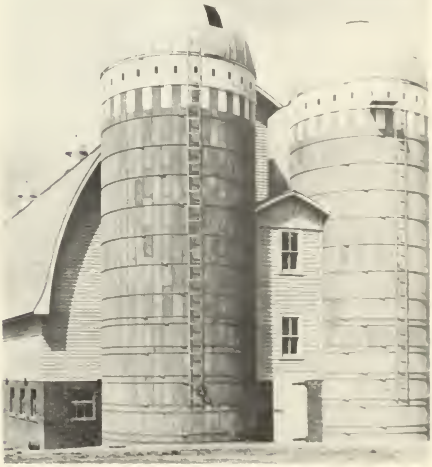

FIGURE 9.—Concrete-stave silo.

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Metal Silos

Metal silos give good service if properly cared for. To prevent corrosion by silage acids, keep the inside painted with boiled or raw linseed oil or a refined tar or asphaltic preparation. Some of the new plastic paints may provide longer protection, but they have not been in service long enough to determine if they are economical for silo walls. Anchor metal silos firmly to avoid wind damage while they are empty. In cold climates, silage freezes more readily and to a greater depth in metal silos than in most other silos, but it also thaws more rapidly. You can probably purchase a metal silo complete near where you live. You may have the manufacturer put it up or you can do the work yourself with the help of 2 or 3 handymen.

Tile Silos

Tile-block silos (fig. 10) are built of hard-burned or glazed tile especially molded to fit the curve of the wall. When well constructed of sound tile, they are very durable and require little upkeep. As special training is needed to build these silos, it is advisable to contract for the silo erected and complete.

Tile-stave silos also are available. They are set up with special dowel locks and mastic calking between the staves. The reinforcing is applied as hoops on the outside. Since neither staves nor calking is affected by silage acids, these silos have a long life with a minimum of maintenance. The sale price of these silos should include erection.

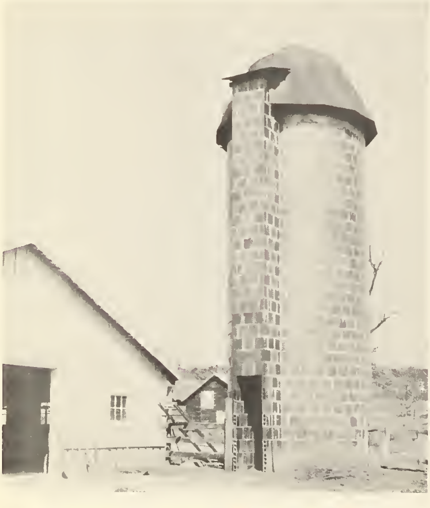

Figure 10.—Tile-block silo with tile chute.

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Brick Silos

Good hard-burned bricks are suitable for silos if you can obtain them at reasonable cost and if laying is not too expensive. Cull paving bricks have also been used satisfactorily. Brick silos may be built with either single or double walls. The single wall 4 inches thick is most common, since it requires less material and labor.

Manufactured door frames, ladder rungs, and bolts to go with fabricated reinforcing bands can be purchased. The fabricated reinforcing is in the form of flat corrugated bands curved to fit silos of different sizes. If you cannot obtain such reinforcing, use rods or wire as recommended in table 9. Place the reinforcing between courses, spaced to give the necessary strength. For a tall silo that requires large reinforcing per foot of height, it is better to use smaller wire or rods in each course or in alternate courses than to increase the size of the mortar joints to care for heavy reinforcing.

Although you may use metal or wood chutes, brick chutes are better. Bond them to the silo wall with metal ties or brick and support them on steel I-beams. You may obtain detailed instructions for building brick silos from the Brick Manufacturers' Association, Cleveland, Ohio.

Wood-Stave Silos

The wood-stave silo is the most popular of the silos built of wood. Wood is not attacked by silage acids and is, from that standpoint, an ideal material. Wood swells and shrinks, however, as it takes up and gives off moisture. This often leads to windstorm damage when the silo is empty because the hoops become loose when the silo dries out. On the other hand, unless the hoops are loosened when the silo is filled, the edges of the staves may be crushed as the wood swells from absorbed moisture and, in extreme cases, the staves may buckle inward.

Of the various woods available, redwood, cypress, longleaf pine, white pine, cedar, and Douglas fir are generally considered best for silo staves. Creosoting makes less-durable woods more resistant to decay and reduces the shrinking and swelling caused by moisture changes.

Some silo companies offer a stave silo wound with a solid spiral wrapping of wood. These silos are more resistant to wind damage since the wood wrapping supports the staves when the silo is empty.

Wooden-Hoop Silos

The wooden-hoop silo is made with hoops of thin boards lined with plywood or with 1- or 2-inch vertical tongue-and-groove sheathing, preferably 2-inch. If 1-inch material is used, two thicknesses, with building paper between, are recommended. Short lengths of milled staves are often used—shorter than can be used in regular stave silos.

Anchoring the Foundation Wall.—Four to six anchors of 3/8- by 1½-inch strap iron 46 inches long, with the lower end bent out 2 inches, should be embedded in the foundation wall. Drill two holes for ½-inch bolts in these irons, one 2 inches and the other 24 inches from the upper end. Place the anchor irons (figs. 3 and 12) in the foundation wall 2¾ inches farther from the center of the silo than the inside of the silo wall, with the lower hole 4 inches above the foundation, so you can bolt them through the two lower loops to the silo wall.

Building the Form for Hoops.—The hoops are made on a form. To build the form, drive a 2- by 4-inch stake and saw it off 1 foot from the ground. Fasten one end of a strip a few inches longer than the radius of the proposed silo to the top of this stake, using a tenpenny nail. Measure from the nail 1-inch longer than the radius of the silo, and cut the strip off at this point. One inch toward the center from the outer end of the strip, drive a 1- by 4-inch stake about 20 inches long, swing the strip halfway around the circle, and drive a similar stake in line with the first and the center stake; swing the strip quarterway around and drive a third stake, and place a fourth stake opposite the third stake. Drive additional stakes around the circumference so that the space between stakes is about 2 feet (fig. 11). Fasten to these stakes 2- by 4-inch uprights about 6 feet long, with their outer edges plumb and flush with the end of the measuring strip. When all the uprights are in place, remove the measuring strip. Tie opposite uprights at the bottom with 1- by 1-inch strips of edging material cut to the exact diameter of the form, which is the same as the outside diameter of the silo wall. Mark these strips in the middle. Nail the lowest one at this point to the top of the center stake and nail the remaining strips to each other at these marks. Beginning about 4 feet from the ground, tie the upper parts of the uprights in the same way. Plumb the uprights and brace them to each other, and run about four braces from the uprights to the center stake.

Making the Hoops.—The hoops should be of 4-inch oak, elm, ash, pine, or chestnut strips ½-inch thick or a trifle thinner. They are usually made 3-ply, except for extremely tall and wide silos for which 4-ply hoops are used.

To build the hoops, make a mark on the outside face of one of the uprights about 6 inches above the ground. Level around from this mark with a carpenter's level, marking each upright. The marks indicate the position of the upper edge of the first hoop. Now fasten one end of the hoop material to one of the uprights so that it will bend around the form to the left (fig. 11); nail it to each upright with the upper edge flush with the mark. At the third upright begin the second ply of the hoop, at the sixth the third ply; bend the boards around the form, nailing to each upright with eightpenny nails and between the uprights and at the joints with sixpenny nails. Break the joints. Fit butt joints in the outer layer carefully. Start the second hoop on the next stud to the left of where the first hoop was started, and continue as before. The number of hoops required is one-half the height of the silo, in feet, plus 1. Thus, a 30-foot silo requires 16 hoops.

When you have completed all the hoops, number them from the bottom up and draw perpendicular lines in four places to assist in plumbing the hoops when you raise them in position. Tear out the form and clinch all nails in the hoops. To protect the joints from weather, place pieces of galvanized iron 12 inches long over all joints in the outside layer of each hoop and nail with galvanized brads. Place the hoops on the foundation in the same order and position as on the form, with one of the perpendicular lines immediately on the left of the proposed door opening. Then erect the inside scaffold so that you can place the hoops in position.

Spacing the Hoops.—On the ground splice four staves, each equal to the height of the silo, and mark on them the spacing of the hoops. Make the marks for the first hoop 6 inches from the bottom of the stave; the next three marks 23 inches apart, and the remainder 24 inches, except the last two, which should be 23 inches. Place these staves in position on the foundation, each one flush with one of the perpendicular lines drawn on the hoop, and nail them temporarily to the bottom hoop. Now raise the top hoop with ropes and nail it in position to the tops of the spacing staves, supported by 2- by 4-inch pieces to the scaffold. Raise the remaining hoops and fasten them to the spacing staves in their proper positions. Starting on the left of the proposed door opening, plumb the hoops at the spacing staves, and brace them to the scaffold.

Placing the Staves.—Carefully plumb the first stave and nail it on at the left of the door opening. Nail the staves on as flooring is laid, driving the tongue into the groove, and blind nail to each hoop with two nails. (See fig. 12.) Break the joints in adjoining staves, and make all joints on

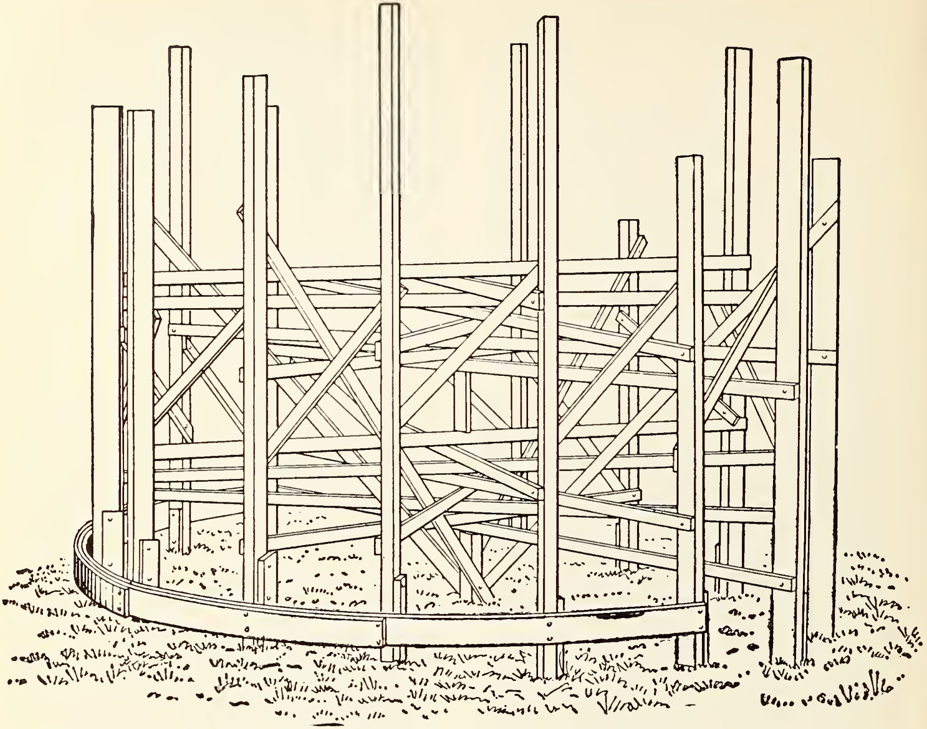

Figure 11.—Form for building hoops for wooden-hoop silo.

hoops. Plumb the edge of the staves about every 5 feet around the wall, and continue nailing the staves on until you reach the opposite side of the door opening. Make this opening about 35 inches wide to allow for fitting in the doorjambs and doors 24 inches wide. Remove the temporary spacing staves as the sheathing of the wall progresses to them. Bolt the silo to the foundation, as shown in figure 12, running ½- by 3¼-inch bolts through the staves, hoops, and anchor irons.

Building the Doorjambs.—Cut pieces of 1- by 4-inch lumber 35 inches long, bevel the ends to fit the inside curve of the hoops, and nail the ends of one of these pieces across the opening on the inside of the upper hoop and one on the inside of the lower hoop. Fit the remaining pieces in the same way and place them in position on the hoops; plumb carefully and nail into place (fig. 13). These pieces form stops for the tops and bottoms of the doors. After these cross-pieces are in place, nail an additional stave on each side of the opening. Next prepare two other staves for the doorjambs by removing the tongue from one of them and the groove from the other and fasten them into place on each side of the opening. Be sure that the finished door opening is uniform in width from top to bottom. On the inside of the doorjambs and 1 inch back from the edges of the door opening, fasten 1- by 3-inch strips the back edges of which are beveled toward the wall.

Figure 14 shows a wooden-hoop silo made of short staves with braces between the hoops.

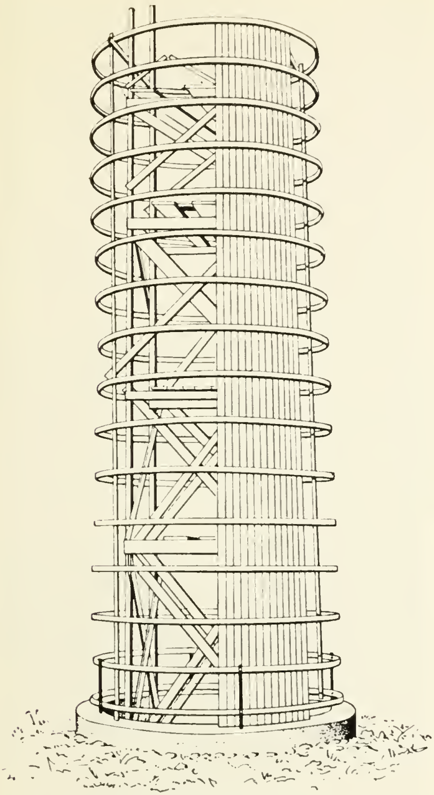

Figure 12.—Wooden-hoop silo started with scaffolding, hoops, and several staves in place.

HORIZONTAL SILOS

Horizontal silos (fig. 15, *A*, *B*, and *C*), both surface and belowground types, are used in all parts of the country as temporary and permanent storage. As temporary storage, the aboveground stack and the belowground unlined trench have the advantage of being readily available for emergency use, but because of the greater exposed surface and the extreme care needed to pack the shallow depth, spoilage may range from 10 to as high as 30 or 40 percent. Another disadvantage of these silos is the difficulty of feeding the silage out during wet weather or spring thaws. In some cases the

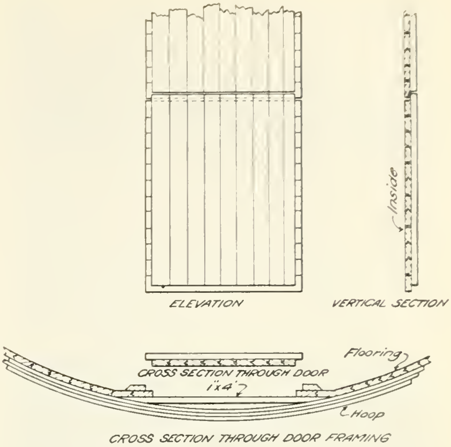
ELEVATION
VERTICAL SECTION
Inside
Flooring
CROSS SECTION THROUGH DOOR
1"x4"
Hoop
CROSS SECTION THROUGH DOOR FRAMING

Figure 13.—Details of door and doorway for wooden-hoop silo.

Figure 14.—Completed wooden-hoop silo with short staves.

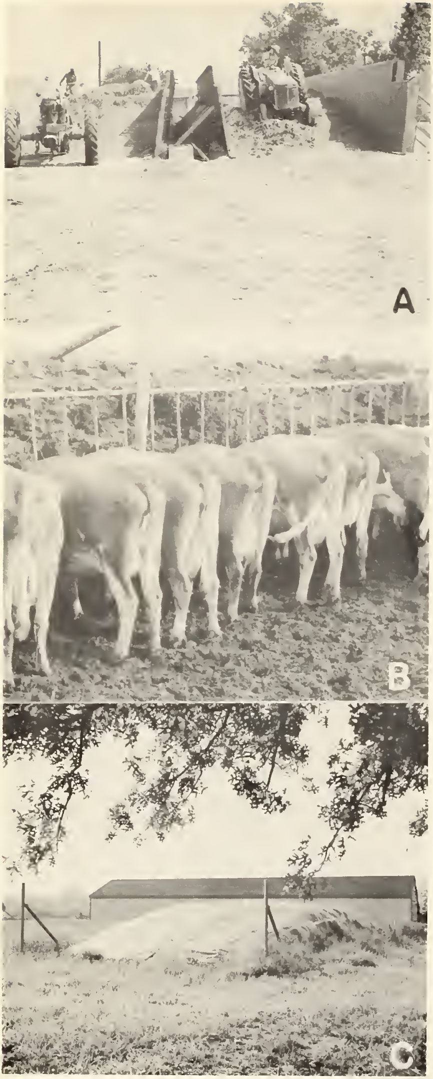

Figure 15.—*A*, Horizontal surface or bunker silo; *B*, trench silo with hanging gate for self-feeding; *C*, stack silo.

A, BN-6788; *B*, Courtesy Univ. of Md.; *C*, N-29019

mud gets so deep that feeding is practically impossible.

Recently, considerable interest has been displayed in permanent horizontal surface or bunker-type silos and in lined trench silos because of their lower first cost, ease of filling, and unloading with mechanical equipment available on most farms. The practice of self-feeding from horizontal silos by placing a feeding gate across one end of the silo is desirable. Self-feeding can reduce the time and labor of feeding silage to a few minutes a day. In the past dry-matter losses in permanent horizontal silos usually ranged from 15 to 30 percent, as compared with 10 to 20 percent in upright silos. Covering the silage to seal out air and water reduces dry-matter losses to a figure comparable to upright silos.

Filling and Packing.—Many failures with bunker, trench, and stack silos occur because of lack of care in filling, packing, and sealing the silage against the entrance of air and water. The silo can be filled with either chopped or long forage. If the forage is to be chopped, a stationary cutter and blower can be used. However, because they require less labor, field choppers that cut the standing forage and chop it in the field or that pick up the forage from the swath or windrow are in more general use.

Unloading at the silo is no problem if you haul the forage to the silo in dump trucks or self-unloading wagons. If you use other trucks or trailers, place a mesh wire, canvas, or rope mat on the vehicle before you load the forage. At the silo attach one end of a line to the front end of the mat and the other end of the line to a tractor; use the tractor to roll the load of forage off the vehicle. Move long forage to the silo by buck rake.

Chopped forage can be leveled and spread easily either by hand or by a cultivator or scraper blade attached to the packing tractor. Level each load as you place it in the silo, and keep the packing tractor in operation continuously during filling. Level and pack long forage continuously between loads to provide compaction and, if you move it by truck, to keep the forage from getting caught on an unprotected drive shaft of the truck.

Green forage that is loaded with a hay loader is difficult to level in the silo and requires more hand-labor.

Thorough packing is necessary to make good silage and to reduce surface spoilage. Pack each load as it is placed in the silo. In addition, continue packing about a half hour in the evening after the last load has been put in the silo, and start in the morning about a half hour before the first load comes in from the field. Cover the silage as soon as the last load is packed. Keep the surface of the forage a little low in the center during filling but crown it from 1 to 2 feet on top when filling is completed, so that a trough will not appear down the center after it settles. The better the job of packing, the less the silage settles, and the smaller the crown that is needed. Well-packed forage with a moisture content of about 75 percent has a density of 45 to 50 pounds per cubic foot.

Covering the Silage.—Top spoilage is caused by molding, rotting, and undesirable fermentation in the presence of oxygen from the air. To be effective, the cover must seal out air and water.

Avoid too long a delay in placing the cover on the silage, because the top material dries out and starts to spoil quickly in warm weather.

Many covering materials have been used successfully when properly applied, but none are effective under all conditions. A layer of well-packed high-moisture weeds or poor forage used to top out the silo will spoil and effectively seal the surface of the silage from air; however, leaching will occur, and gas fermentation losses will be higher than with a waterproof cover. If the top of the silage is well crowned, most of the water will run off the edges.

A layer of soil or ground limestone at least 4 inches thick makes an effective cover for well-crowned silage, but it should be wet down if it is placed on the silage during a dry spell. The biggest objection to this kind of cover or weighting material is the labor required for removal when the material is frozen.

Black polyethylene and polyvinyl chloride film plastics for covers are now available generally from building and farm supply stores and also from mail-order houses. The low cost of these materials and their effectiveness when properly used, make it possible to store ensilage in horizontal silos with no more loss than in tower silos.

To get the most value from a plastic cover, it must be sealed along all edges and weighted over the entire surface. Sawdust or chopped forage makes effective weighting material. Old tires scattered over the surface and along the edges will help hold the weighting material in place. To insure a good edge seal, place two strips of plastic extending down the silo walls during filling. These strips can be wide enough to extend across the silo and form the top cover, or they can merely extend 2 or 3 feet on the top of the silage and be covered by a top cover strip. This procedure gives added protection to the shoulders of the silage mass, and is especially valuable where wilted silage is being placed in a horizontal silo.

Plastic-coated fabrics and Butyl rubber sheets have also made excellent silo covers. They are more expensive and must be used for several years to reduce their annual cost. However, they are more durable, and, because of their weight, do not require as much weighting material.

Weight any cover to keep it from flapping up and down in the wind. Flapping causes a pumping action that circulates air from a very small leak or puncture over the entire surface of the silage. Weighting is important also in preventing air from contacting the entire surface of the silo when it is opened for feeding.

Feeding the Silage.—Silage can be fed or self-fed from horizontal silos as follows: (1) By placing feeding gates across one or both ends of the silo; (2) by using tractor forks or horizontal silo unloaders to load silage into trucks, bunks, or feeders; (3) by hand with silage carts; and (4)

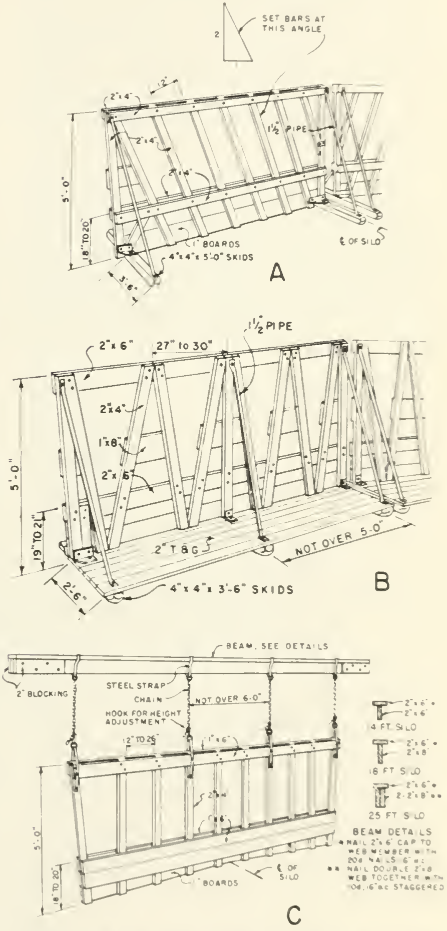

FIGURE 16.—Feeding fences for horizontal silos: *A* and *B*, self-supporting fences; *C*, hanging fence to be supported by a pole or pipe across the top of the silo.

by a combination of tractor forks and self-unloading wagons or conveyors for loading silage bunks or feeders.

If the silage is to be fed by hand with a silage cart, extend a paved walk from the silo to the barn or feeding area.

If the silage is to be self-fed, extend the silo floor to the paved barnyard or make it a part or an extension of the feeding floor.

Figure 16 shows three feeding fences for horizontal silos. Self-supporting fences (fig. 16, *A* and *B*) can be moved up to the face of the silage as the animals clean up the silage within reach. Bars placed at an angle, as in figure 16, *B*, tend to keep the animals from stepping back and dropping silage in front of the fence. Many farmers prefer a hanging fence (fig. 16, *C*) because it is easier to move.

Figure 17 shows feed bunks built for tractor-fork feeding. They should be large enough to prevent spillage and should be placed along the fence of the feedlot or on either side of a drive through the feedlot so they can be loaded without driving among the animals.

Size and Capacity.—The cross-sectional area of a horizontal silo should be proportioned to the size of the herd and weight of silage to be fed daily. (See table 10.) Adjust the length to suit the amount of silage required for a given feeding period, with an allowance for spoilage. In an unlined trench silo that is to be used each year, make the cross-sectional area small enough to allow for trimming and evening the sides before filling without increasing the capacity beyond the daily feeding requirements.

Corn or grass silage in a horizontal silo, well packed by tractor or animals, weighs from 40 to 50 pounds per cubic foot. The exact weight depends on the material, its moisture content, whether it is chopped or long, the fineness of chopping, and the care with which it is packed.

Table 10 gives the dimensions, cross-sectional area, and weight of silage per 4-inch slice and per 12-inch slice for horizontal silos with various depths; the silage is assumed to weigh 40 pounds per cubic foot, and the rate of feeding is assumed to be 4 inches lengthwise of the silo per day. If the silage is to be fed only in cold weather, when the exposed surfaces will not spoil, the size of the cross-sectional area of the silo can be increased and only 2 or 3 inches of silage need be fed per day.

The width of a horizontal silo is also influenced

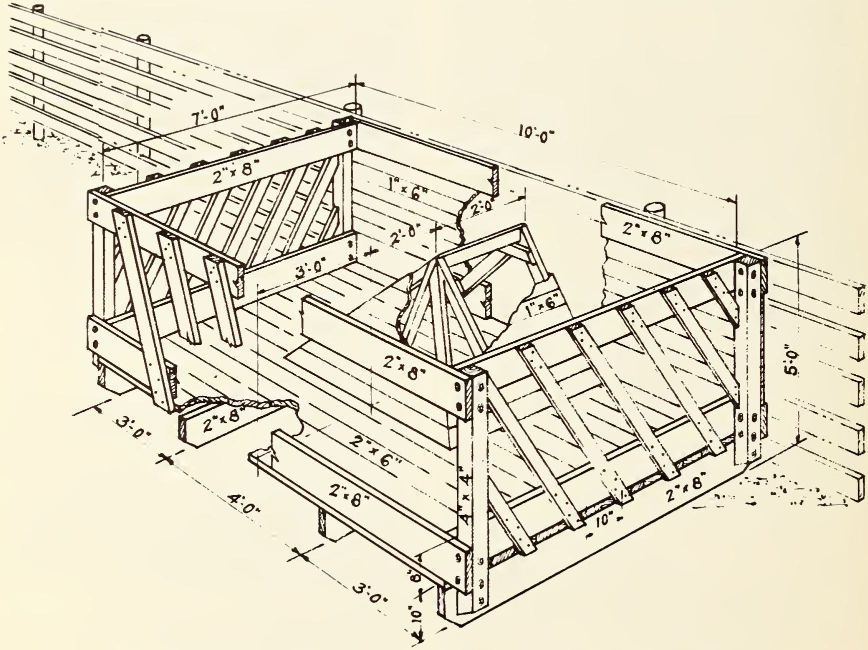

Figure 17.—Rectangular feed bunk that can be filled with a tractor scoop without spillage.

by the method of filling and whether the silage is to be self-fed. If you fill the silo with chopped roughage, the silo need be just twice as wide as the tread of the tractor used for packing. However, if you use a three-wheel tractor for packing, the silo can be 1½ times as wide as the tread of the rear wheels of the tractor. If you put uncut roughage in the silo with a buck rake, the silo should be the same width or twice as wide as the rake. If you use a high-lift buck rake to dump the forage over the walls of a bunker silo, the width of the packing tractor governs the width of the silo. If you are going to self-feed the silage, allow from 3 to 6 inches of silo width per head of stock.

TABLE 10.—*Dimensions, cross-sectional area of horizontal silo, and weight of silage in 4-inch slice and per lineal foot*[1]

Side slope per foot of depth (inches)	Depth	Bottom width	Top width		Cross-sectional area	Weight of silage	
						4-inch slice	1-foot slice
	Feet	*Feet*	*Feet*	*Inches*	*Square feet*	*Pounds*	*Pounds*
1½	4	6	7	0	26. 0	346	1, 040
	4	10	11	0	42. 0	560	1, 680
	6	8	9	6	52. 5	700	2, 100
	6	12	13	6	76. 5	1, 015	3, 060
	8	10	12	0	88. 0	1, 173	3, 520
	8	14	16	0	120. 0	1, 600	4, 800
	10	12	14	6	132. 5	1, 767	5, 300
	10	16	18	6	172. 5	2, 300	6, 900
3	4	6	8	0	28. 0	373	1, 120
	4	10	12	0	44. 0	587	1, 760
	6	8	11	0	57. 0	760	2, 280
	6	12	15	0	81. 0	1, 080	3, 240
	8	10	14	0	96. 0	1, 280	3, 840
	8	14	18	0	128. 0	1, 767	5, 120
	10	12	17	0	145. 0	1, 933	5, 800
	10	16	21	0	185. 0	2, 467	7, 400
4	4	6	8	8	29. 0	387	1, 160
	4	10	12	8	45. 2	603	1, 808
	6	7	11	0	54. 0	720	2, 160
	6	12	16	0	84. 0	1, 120	3, 360
	8	10	15	4	102. 7	1, 369	4, 108
	8	14	19	4	134. 7	1, 796	5, 388
	10	12	18	8	153. 3	2, 044	6, 132
	10	16	22	8	193. 3	2, 577	7, 732

[1] For silage weighing 40 pounds per cubic foot.

Bunker Silos

The decision to build a bunker silo should be based on a consideration of the farm operation in connection with the following specific advantages and disadvantages under the farm practices followed:

Advantages.—Bunker silos—

Can be located with less regard to terrain than trench silos.

Can be built with farm labor.

Cost less than upright silos.

Are adaptable to self-feeding.

Are adaptable to mechanical feeding with tractor fork.

Can be filled with either long or chopped forage.

Do not require a blower for filling.

Can be packed mechanically with tractor or truck equipment.

Disadvantages.—Top spoilage in bunker silos is from the same to several times greater than in upright silos.

Removing top cover and any spoiled silage is a continuing operation while silage is being fed out.

Because of their shallow depth as compared with upright silos, care must be used in distributing and packing silage to prevent excessive spoilage.

Cover must be effective in keeping out rain and water from melting snow, to prevent leaching.

Unless a roof is provided, feeding is disagreeable during bad weather.

Bunker silos cost more than trench silos.

Selecting the Site.—Build a bunker silo on a comparatively level, well-drained site, close to the barn or feedlot.

Select a site that is easily accessible from the fields and that has adequate turning space for the trucks and tractors used to haul and pack the forage. Time and labor required for filling is reduced if the equipment can be driven through the silo during filling and packing.

Provide adequate drainage to remove excess juices and rainfall from the site, also cutoff drains to prevent surface water from draining into the silo.

Building the Silo.—Build the bunker silo with tight, rigid walls and a solid floor. The type of construction depends on the availability of materials, labor, and tools.

Walls.—The most critical part of a bunker silo is its walls, and the most critical part of the wall is its support.

The wall must have sufficient strength to support the weight of the silage and the weight of the filling and packing equipment. Little information on the lateral pressure imposed by silage on the walls of bunker silos (as affected by the many kinds of crops used for silage) is available. However, the kind of forage placed in the silo, its moisture content, whether it is stored chopped or long, the fineness of chopping, the thoroughness of spreading and packing, and the weight of the packing tractor all affect the density of the silage and the lateral pressure on the silo walls.

Slope the walls outward just enough to keep the mass of silage tight against the walls as it settles. A slope of 1½ inches per foot of depth is sufficient if the silage is well distributed and packed.

The walls may be made of concrete, masonry, or treated lumber. (Lumber used in bunker silo construction should be pressure treated with creosote, penta or other commercial preparations to 8 pounds' retention of solution per cubic foot of lumber.)

Earth-walled surface silos are serviceable for emergency use in areas where the soil is firm enough. However, they should be either carefully compacted or placed in service a year before being lined. The earth-walled silo shown in figure 18 has a concrete floor and rubble-stone approach. One wall has been dressed, or smoothed, ready for filling; the other is still to be dressed. The walls are to be lined with concrete at a later date, and the silo will be used for self-feeding.

Figure 19, *A* to *E*, shows different types of construction for bunker-silo walls and shows how various materials can be used to build silos of any length and width. The plans are designed to meet the severest weight conditions likely to be encountered for the height of wall shown. Any increase in height must be compensated for by strengthening the wall section.

The cantilever post construction shown in figure 19, *A*, is based on the use of structural grade timbers. If structural grade timbers are not available, larger posts are required. Round posts should have a cross-sectional area at the floorline equal to the timber shown, which in this case would require a post 7¾ inches in diameter or 24⅜ inches in circumference. Set the posts solidly and deep enough to prevent sagging or overturning. If you can use a concrete floor, it is good practice to anchor the posts to the floor. This decreases the depth to which the base of the post must be set.

In heavy, good-bearing soils, a post set 3 feet deep and anchored to a concrete floor slab is adequate. In lighter or wet soils, brace the post, set it in concrete, or place a wooden kicker at its bottom. If you cannot obtain heavy posts, use braced posts (fig. 19, *B*, *C*, and *D*). The braces must have adequate bearing for the type and condition of the soil. As the foot of the brace is near the surface, allow for changes in the moisture content of the soil. A brace bearing that is adequate for dry soil conditions might fail when the soil becomes wet. Wood or concrete bearing blocks increase the bearing area of braces.

As a safety feature, extend the posts 1½ to 3 feet above the silo wall and join them with a 4- by 4-inch guardrail. The rail tends to keep the tractor from going over the edge of the silo and provides a definite mark of the edge of the silo for the tractor operator as he is completing the packing when the silo is full. The posts and rail can be used to support one end of a shade or roof for protection against bad weather. The rails can also be used as a basis for shelter for young stock or as a support for a hanging feeding gate.

If you set cantilever posts 6 feet apart on centers and apply sheathing horizontally, use either 2-inch square-edge or 2-inch tongue-and-groove sheathing. Apply the sheathing in 12- or 18-foot lengths to span the spaces between 3 or 4 posts; and break the joints. If you use square-edge sheathing, the walls must be covered with roll roofing or other impervious material to make them airtight.

Handle tongue-and-groove sheathing carefully. If the edges of the plank are damaged or warping prevents a tight, close-fitting joint, cover this sheathing also.

Floor.—A bunker silo should have a solid floor that will not turn into a mudhole in wet weather or when the ground thaws. Concrete, asphalt, or treated lumber makes a long-lasting, easy-to-clean floor. One advantage of concrete is that you can

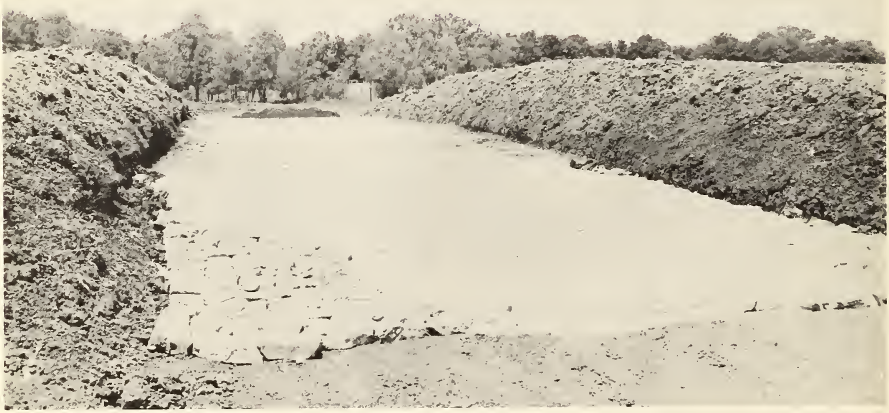

FIGURE 18.—Earth-walled surface silo in Louisiana. BN-6779-X

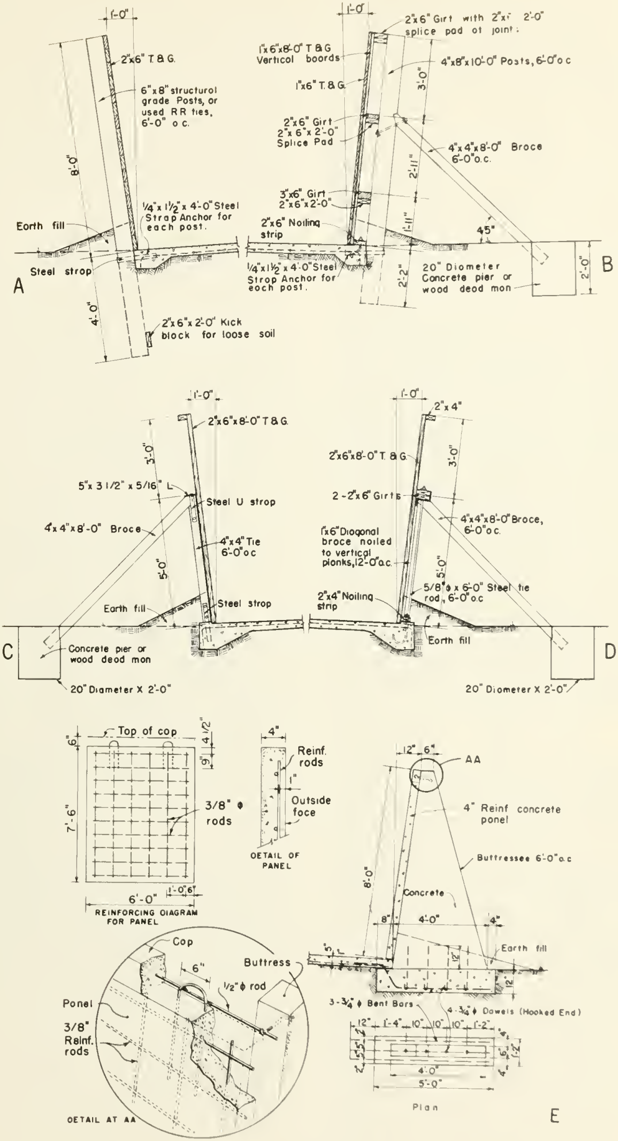

Figure 19.—Different types of walls for bunker silos; *A*, Cantilevered post and plank; *B*, braced post and wood girts; *C*, braced steel angle girt with vertical plank; *D*, braced wood girts with vertical planks; and *E*, concrete buttress with reinforced concrete wall.

anchor wall posts in it at ground level. Lay asphalt flooring 3 to 4 inches thick on a well-rolled subbase 6 to 8 inches thick.

A horizontal silo that is built to store surplus feeds in an emergency should at least have a floor of crushed rock or gravel. This type of floor forms a good base for a concrete or asphalt floor to be added later.

Crown the floor slightly; slope it one-fourth inch per foot from the center to each side. Also, slope it sufficiently from one end to the other to provide adequate drainage. If possible, slope the floor to conform to the natural grade to eliminate cut and fill. If you feed out the silage by hand or mechanical equipment, a slope of ¼ inch per foot is enough. If you self-feed from one end only, the slope should be from ⅜ to ½ inch per foot. If you self-feed from both ends, slope the floor from the center to each end. This practice is not recommended because it makes the silo more difficult to drive through when filling.

Roof.—Losses by leaching in horizontal silos often are considerable. Covers placed on the silage to exclude air and prevent top spoilage may not exclude all water if settling occurs, if the silo is not completely full. A roof over the silo to drain off rain and water from melting snow helps to minimize or prevent losses by leaching.

The roof must either be removable or high enough to provide headroom for filling and packing equipment. If you build the silo in conjunction with a shelter, you can place a fixed roof over the silo at a minimum cost, and store baled hay or bedding in the space above the silage. Lightweight hinged or removable panels placed over the silo are effective in keeping rain and snow off the silage, and they also provide protection from the weather when feeding out the silage.

Trench Silos

Trench silos have several advantages. An unlined trench silo can be made for labor cost only, so that almost any farmer can afford one. With power equipment, it can be made quickly in emergencies. Repairs are limited to smoothing the walls and cleaning the drains. It is adaptable to small herds and can be filled with uncut forage or with forage cut with a small stationary cutter, with or without a blower, or a field chopper. This type of silo affords easy access to the silage. It can be built as a temporary silo and lined for permanent use later.

A disadvantage is that spoilage may range from 10 to 25 percent. Also, unless lined, the side walls tend to cave, and when rain occurs during the feeding season the bottom of the trench may become muddy and make entrance to the trench so difficult as to require a temporary road of planks. Like other horizontal silos, special care is necessary in packing the silage, and suitable drainage must be supplied if the site does not have adequate natural drainage. The open trench is dangerous unless fenced or roofed, and it is not easily filled in when abandoned. Special care must be taken to guard against suffocating gases in the bottom of a trench silo, especially when it is dug in level ground. *See the warning on page 27.*

Cost.—The only cost of constructing an unlined trench silo is the labor required to dig out the trench. The time required depends on the size of the silo, the type of soil, and the equipment used. One man using a tractor and pullover scraper can move about 40 cubic yards of heavy clay soil in an 8-hour day or 60 cubic yards of light clay or loam. Use of a blade on a crawler tractor shortens the time considerably.

Estimate the time as follows: Multiply the cross-sectional area (given in table 10) by the length of the trench (in feet), and divide by 27 (the number of cubic feet in a cubic yard). This result is the number of cubic yards of earth to be removed from the trench. Divide this result by 40 (if heavy clay soil) or by 60 (if light clay or loam). The result is the number of 8-hour days required to dig the trench.

Example: Suppose you need 45 tons (90,000 pounds) of silage for your herd and you plan to dig a trench 7 feet wide at the bottom, 11 feet wide at the top, and 6 feet deep. Table 10 gives the cross-sectional area as 54 square feet, and the weight of silage per linear foot as 2,160 pounds.

Calculate as follows: 90,000 pounds of silage plus an allowance of 20 percent for spoilage = 108,000 pounds of silage to be stored.

108,000 ÷ 2,160 (weight per linear foot) = 50 feet (length of silo required).

54 (cross-sectional area) x 50 (length of silo) ÷ 27 (number of cubic feet in a cubic yard) = 100 (number of cubic yards of earth to be removed from the trench).

100 ÷ 40 (if soil is heavy clay) = 2½ days, the time required to dig the trench; or 100 ÷ 60 (if light soil) = 1⅔ days. The job can be done in from ½ to 1 day if you use a blade on a crawler tractor.

Lining the walls increases the cost considerably. Cost estimates are based on the square feet of wall area. In the silo mentioned, the height of the wall including the side slope is 6 feet 4 inches. If allowance is made for an 8-inch footing and a 6-inch curb, the total height is 7½ feet. The total wall area is: 7½ (height of wall) x 50 (length of silo) x 2 (two sides) = 750 square feet.

To cover 750 square feet with 4-inch concrete requires 750 x ⅓, or 250 cubic feet (9.26 cubic yards) of concrete. In addition, 200 feet of 45- or 48-inch hog wire is needed for reinforcing. Concrete usually costs from $15 to $25 per cubic yard in place. For this type of wall you can build a form 10 to 15 feet long and move it along the trench as you complete the sections.

You can estimate for other types of linings for walls of trench silos in the same way.

Selecting the Site.—A trench silo should be convenient to the feed lot or barn, but where it will not interfere with farm operations, be unsightly, or receive seepage or drainage from barns, feed lot, or manure pit. A hillside or slope is desirable because one end may open level with the ground surface, which facilitates removal of the silage and allows water entering the trench to drain out. Drains should be made around the trench to intercept surface water. Where only level ground is available, dig the trench with sloping ends to permit driving in and out during construction, filling, and feeding. Where the ground is impervious, run a drain from the lowest part of the trench to a dry well or to lower ground to take care of water trapped in the trench when it is partly or entirely empty. In some cases water is drained to the lower end of the trench and bailed out. Figure 20 illustrates layouts for trenches dug under different conditions of topography and drainage.

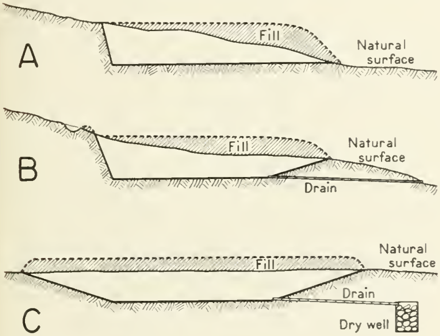

FIGURE 20.—Layouts for trench silos under different topographical conditions: *A*, On a hillside; *B*, on a gentle slope; *C*, on level ground.

Digging the Trench.—After you have staked out the trench, plow the ground, if required, leaving room to smooth down the sides of the trench. Remove the loose ground, generally with a slip or fresno scraper, a tractor blade, or a bulldozer, and plow another layer. If you have a bulldozer, you may not need to plow, continue these operations until you reach the desired depth. If you place the earth removed from the trench along the sides, the ground at the sides will slope away from the trench. This reduces not only the depth of the trench below the natural level of the ground, but also drainage of surface water into the trench.

True the sides and keep them to slope either as you dig the trench or after you reach the bottom. Use bladed grader or a spade and mattock or grubbing hoe.

Another method, especially for emergency use, is to dig a very shallow trench, stack the silage several feet above ground, and cover the silage with dirt from the trench. In some European countries metal forms about 2 feet high are used to hold the silage while the dirt is being banked around it. The forms are raised as the mound is built up, and the top is finally covered with earth. This has the advantage of requiring only a shallow trench, but more labor is required to cover the mound.

Do not slope the sides of the trench more than necessary for the type of soil. A slight slope keeps the silage tight against the sides as it settles; too great a slope hinders settling. Trenches with walls ranging from vertical to almost 45 degrees have been dug. Slopes of 1½ to 4 inches per foot of depth, as noted in table 10, are recommended. If a slope of much more than 4 inches to the foot is required to make the side walls stable, line the walls.

If you are *not* going to line the trench, protect the edges against caving. Set posts at regular intervals and place planks or poles along the edge. Build a fence to keep people and animals from falling into the trench.

If you are going to line the trench later, make the cross section a little smaller than you want for the final silo, depending on the stability of the soil, to allow for truing the walls after use.

It is probably more important to line a trench silo you intend to fill and empty each year than one you are going to use to carry over feed from good years to lean or drought years, since most wall weathering occurs when the trench is empty. If you are going to use the trench to keep feed for several years, provide good drainage to prevent excessive losses.

Lining Trench Silos.—You can line the walls of trench silos with cement plaster, concrete, wood, or masonry (brick, tile, stone, or block) (fig. 21). Wood linings are not very durable unless creosoted, and they are not economical unless local lumber is plentiful.

Where soil conditions are good, cement plaster 2 or 3 inches thick and reinforced with wire mesh makes a good lining. Fasten the wire mesh to the wall with spikes or iron pins. Make plaster of 1 part of cement, 3 parts of sand, and 3 parts of crushed stone or pea gravel. Apply it in horizontal strips 12 to 15 inches high to prevent sloughing. Use horizontal boards as wide as the lining is thick, placed on edge about 2 feet apart along the walls of the trench, to level the surface of the lining. One strip should have time to set before you apply the next. Apply with a trowel a finishing coat of plaster made of 1 part of cement and 3 parts of sand; you may also apply a cement wash. If you want a stronger wall, place a concrete lining 4 to 6 inches thick by using forms and reinforcing, as shown in figure 21, *B*.

If native stone is plentiful, you can make a rubble masonry wall at low cost except for labor. The wall should be 12 to 16 inches thick, and should be laid up with a cement mortar made of 1 part of cement to 6 parts of sand. Cover the surface with ½ to ¾ inch of a 1 : 3 cement plaster (fig. 21, *A*). If you use dressed stones, build the wall 8 inches thick with a 1: 3 cement mortar. You can use brick, block, and tile in the same manner. If there is any danger of the earth walls sliding, place reinforcing rods between courses 18 inches to 2 feet apart, and increase the slope of the wall to 5 inches per foot of depth. Place tile drains alongside the floor slab or footing to help stabilize the earth walls and relieve pressure on the lining.

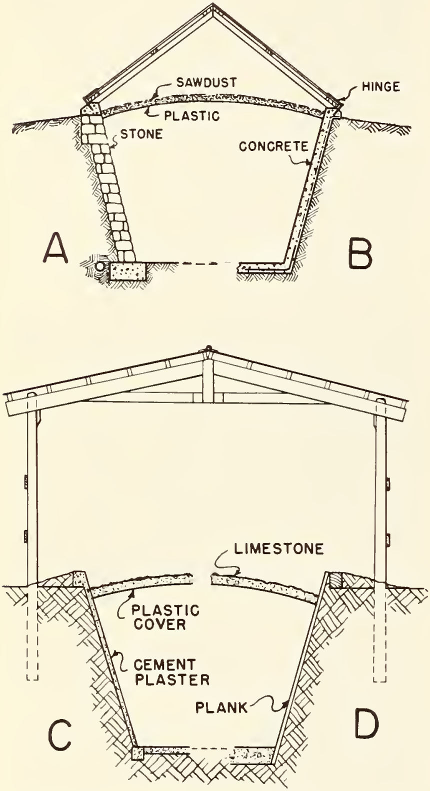

Figure 21.—Different types of lining and roofs for trench silos. Linings: *A*, Stone; *B*, concrete; *C*, cement plaster; *D*, plank. Roofs: *A* and *B*, Wood frames covered with boards or sheet metal; *C* and *D*, pole frame roof, providing storage space for baled hay or straw.

If the ground-water level is close to the surface and the trench silo is extended aboveground by banking (fig. 20), make the wall lining strong enough to prevent cracking.

Stack Silos

Stack silos are generally temporary or emergency silos. However, a stack built on a concrete or other solid platform with good drainage and covered with a plastic film weighted on the top and sides furnishes good silage with little more spoilage than a bunker or trench silo. Silage in rectangular stack silos can be self-fed. Floors or solid platforms for straight-sided stacks are more economical than for sloping-side stacks, but a sloping-sided stack can be packed with much greater safety.

Pack straight-sided stacks thoroughly as they are built, and spread each load of material as you dump it. Keep the tractors at least 1 foot from the edge of the stack while packing. Dress loose material from the edges and throw it on top of the stack. If the stack is more than twice the width of the packing tractor, reduce the top width to increase the safety of the packing tractor operator.

The solid platform for a sloping-sided stack should be as wide as the stack, or the material beyond the edges of the platform should be thrown to the center by hand when self-fed. Apply the cover of a stack silo, like other horizontal silos, as soon as you have packed the last load.

TEMPORARY SILOS

Fence and upright stack silos are used throughout the country to meet emergencies and to supplement permanent silos. They are low in cost, can be erected on short notice, require no special foundation, and can be set on almost any site convenient for filling and feeding.

FENCE SILOS

Use of successive rings of fencing for silos has become widespread in recent years. Fence silos may be lined with plastic or paper, or they may be unlined. Table 11 gives the capacity and the amount of material required for silos of various sizes. The range of capacity covers differences in moisture content, length of cut, tramping, and speed of filling. Diameters in the table are based on the most efficient use of standard-sized rolls of the most suitable types of fence.

Table 11.—*Materials required for lined fence silos of different sizes*

Size of silo		Capacity	Fencing		Length of paper [1] or plastic film
Diameter (feet)	Height (in 4 foot sections of fence)		Pieces	Length of each piece	
	Feet	*Tons*	*Number*	*Feet*	*Feet*
8	3	8–11	3	25	80
10½	3	14–17	3	33⅓	105
12	3	19–25	3	37½	120
12	4	22–29	4	37½	160
16	4	39–52	4	50	212
19	5	70–95	5	60	320
24	7	160–230	7	75	553

[1] Paper 4 feet wide; quantities shown are for corn silage and should be doubled for grass silage.

Use any of the following materials for fence silos that are to be lined: 2- by 4-inch mesh 11- or 12½-gage welded and galvanized steel fabric, 2- by 4-inch diamond mesh lawn fence, or ½- by 1½-inch wooden slat fencing made up with 5 strands of 2 wire cables per 48-inch width. For an unlined fence silo, use any strong small-mesh fencing. Generally the diameter of a silo is based on the size of the herd to be fed. (See tables 1, 2, and 3.)

A heavy paper or a plastic film lining is good insurance against excessive spoilage. Any kind of building or roofing paper, with or without fibrous reinforcement, can be used as lining. Some papers are treated to resist acid and bacterial action. Black polyethylene and vinyl chloride plastic film are more durable and cost about the same. Lining a fence silo reduces spoilage more than half. The lining keeps the silage from falling through the fencing during filling, keeps moisture from escaping, and keeps air from the surface of the silage. Whether lined or unlined, care in chopping silage to short lengths and uniform packing are important in obtaining full feeding value from the forage stored.

Build a fence silo as follows: Lay out the circumference of the silo on ground as nearly level as available in good location, as described under laying out foundations (p. 4). Then level the base circle or the trench, which should be at least 15 inches wide. Place the earth removed in leveling outside the silo walls where it will not affect the even settlement of the walls or the capacity of the silo. Set up the fencing in a true circle, lapping the ends at least two spaces, and fasten the ends together—wire to wire wherever possible. Make sure that no sharp wire ends extend into the silo where they might cut or tear the lining. Place the lining on the inside of the fence so the edge folds in along the bottom and fasten it temporarily to the top of the fencing strip with clothespins or clamps made by nailing two slats or laths together at one end, like an oversized clothespin. Extreme care should be used to have the lining long enough to fit against the fence when it is installed so as to prevent its riding up or splitting when filled with silage.

Now fill this section to within 6 inches of the top. Then place the second section above and slightly inside the first; hold it in position temporarily by binding the fences together about every 18 inches with twine. Place the lining for the second tier so as to lap over the inside of the bottom strip. This allows the silage to settle past the lap without catching. Fill the second section to half its height. Then, with slat-type fencing only, put two No. 9 reinforcing wires around the first tier, pull them snug but not tight, and twist together or fasten with small turnbuckles. Turnbuckles are inexpensive and make it easier to adjust the wires as the fencing stretches and later to salvage the wire. Continue filling and placing the sections until the third section of fence is about half full. The twine ties used to hold the second tier of fencing to the first may now be removed to allow the two sections to telescope into each other as the silage settles. Unless the twine ties are cut, the lining may be torn or the silo may lean.

Handle other tiers in the same manner until the silo is the desired height, usually not more than 4 feet higher than the diameter. If you need additional silage, it is better to plan for two silos than attempt to increase the height beyond these safe limits. A well-constructed welded steel fence silo lined with reinforced paper is shown in figure 22.

Unless you are going to feed the silage within 30 days of filling, provide some sort of covering. Plastic film topped with straw or other waste vegetation makes a good cover. For short periods the plastic may be omitted.

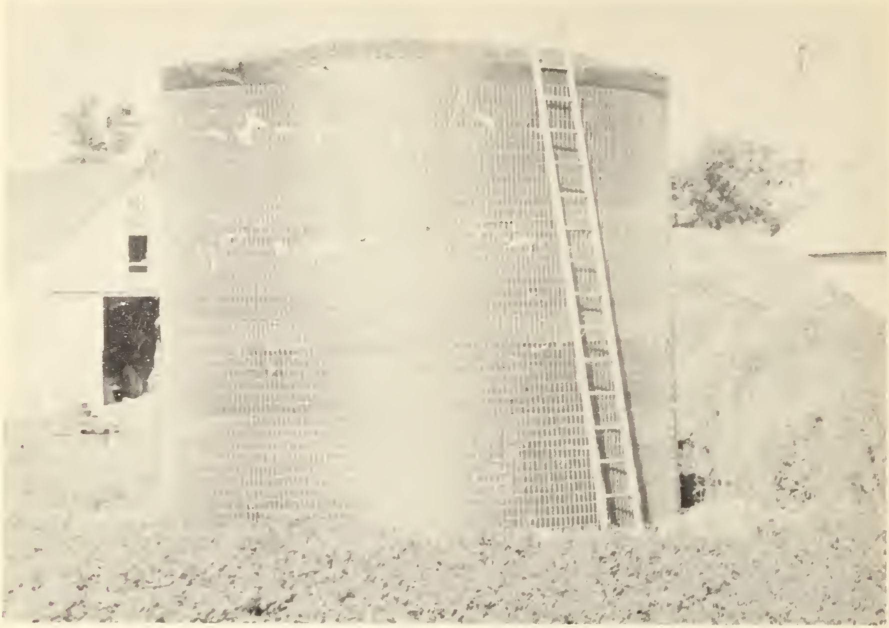

FIGURE 22.—Temporary but well-constructed welded-steel fence silo. BN–6787

UPRIGHT STACK SILOS

If forage is plentiful, upright stack silos can sometimes be used in emergencies despite the prospect of a high percentage of loss. You can store either chopped or unchopped forage in them. Simply stack unchopped forage in the most desirable form. Since losses occur principally around the outside of the stack, the larger the stack the smaller the percentage of loss. Pack the stack as tight as possible to exclude air. It is best to feed out this type of silage by slicing layers off one end of the stack with a hay knife. You can place chopped forage in a shell made of bales of hay or straw, corn bundles, or loose weeds or grass. This method results in less spoilage and the silage is much easier to feed.

Bales of hay or straw used for a silo should be tied together with No. 9 wire, as in a slat fence silo. If you know before you bale the material that you are going to use the bales to build a silo, make curved bales by tying one of the bailing wires shorter than the other. Tying one wire 6 or 7 inches shorter than the other gives curves suitable for about a 16-foot silo.

WARNING—GAS DANGER IN SILOS

Suffocating and, in some cases, poisonous gas may be present around silos. Suffocating gas from fermenting silage, mostly carbon dioxide, forms in all silos shortly after filling begins and continues until fermentation stops. Poisonous gas when present is nitrogen dioxide. Its color and density vary with its temperature. At room temperature it is orange yellow and 2½ times as heavy as air. As the temperature rises its color becomes darker and its density becomes lighter. The gas, being heavier than air, collects and remains in any depression or enclosed space when there is not a strong, free movement of air.

Many lives have been lost because of carelessness in entering a silo where there may be danger of gas. Gas is a particular hazard in the belowground silo. The aboveground silo, while not free from gas danger, offers better ventilation through its doors, and large quantities of gas seldom accumulate unless the doors are put in too far above the silage level.

During and immediately after the filling period, run the blower on the silage cutter several minutes before anyone enters the silo. In a deep pit or in any silo into which the distributor pipe does not extend far enough to agitate the air thoroughly, observe carefully to sight any yellowish-orange gas or discoloration that might indicate nitrogen dioxide gas. You can make an easy test for nitrogen with starch-iodide paper, which turns blue in the presence of nitrogenous compounds. If the paper turns blue when you lower it to the bottom of the silo, stir the air to disperse the gas. You can usually obtain starch-iodide paper from drug stores or chemical supply houses. To test the air for carbon dioxide, lower a lighted lantern to the bottom. If the lantern continues to burn, it is safe to enter the silo. If the lantern goes out, do not enter until the air has been stirred to dilute the gas. To stir the air, tie to a rope some object such as a basket, a blanket, a large piece of canvas, or a tree branch, and drop it into the silo and raise it a number of times.

Nitrogen dioxide gas, when breathed in sufficient quantities, causes coughing, a choking sensation, and a feeling of extreme weakness. Two or three weeks after exposure the victim may get better or he may show symptoms similar to pneumonia. If you suspect the presence of nitrogen dioxide and feel any illness, consult a doctor. Danger of nitrogen dioxide gas occurs only during filling and for about a week after.

A victim of carbon dioxide gas suffers from lack of oxygen. Move him into fresh air as soon as possible and apply artificial respiration. Before a rescuer enters the silo, tie a rope securely to him in case it may be necessary to pull him out. Send for a physician, but in the meantime do not relax efforts to restore breathing by methods given in your first aid guide.

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